Mechanical Response of Chondrocytes to Cyclic Loading
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INTRODUCTION
Chondrocytes are responsible for the elaboration and maintenance of the extracellular matrix in articular cartilage. The biosynthetic responses of chondrocytes are known to be regulated by mechanical loading; therefore, mechanical properties of the cells play a pivotal role in the regulation of articular cartilage. Cartilage is unlike any other tissue in the human body since it lacks blood supplies and has low intrinsic regenerative properties. As a result, cartilage structure and function is more likely to degenerate in response to aging. We have hypothesized that functional deterioration observed in adult tissue is due in part to age-dependent changes in mechanical stiffness. To test this we: 1) investigated the indentation-dependent response of bovine chondrocytes to mechanical cyclic loading at different resting intervals using atomic force microscopy; 2) measured the effects of age on this response.

RESULTS and DISCUSSION
Indentation-dependent curves were fit to a non-Hertzian model (Fig. 2A and 2B), where the indentation dependent compressive stiffness was empirically calculated, and the Hertzian model (Fig. 2C), which assumes a constant compressive stiffness. When the mechanical properties of single chondrocytes isolated from 1 day bovine were evaluated as a function of the resting time between successive cyclic indentations (relax time), the compressive modulus of cells drastically decreased between a relax time of 0.5s and 2s (Fig. 2). These results suggest that immediately after cyclic indentation chondrocytes experienced a higher stiffness that decreased with increasing relaxation time. This relaxation behavior may be due to fluid pressurization inside the cell or viscoelastic elements in the membrane or organelles. To determine if this response was due to the viscoelastic elements of the chondrocytes, the same experiments will be conducted after disrupting the three structural components of the chondrocytes, actin, tubulin and vimentin.

The structural integrity of articular cartilage has been shown to decrease with age, which may be due in part to changes in the biomechanical properties of chondrocytes. To address this question, the same experiments described above is being conducted on chondrocytes isolated from different aged bovine; immature (1-3 week old bovine calf), young (1-2 year old bovine) and aged (5-7 year old bovine). The results from this work will help illuminate if the biomechanical properties of individual chondrocytes contribute to the age-dependent deterioration in the structural properties of articular cartilage.

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